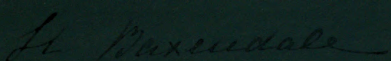
LECTURE ON SWITZERLAND.



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From the Author

A LECTURE ON SWITZERLAND.

LONDON:
Printed by SPOTTISWOODE & Co.
New-street Square.

A

LECTURE

ON

SWITZERLAND.

BY W. LONGMAN.

(PRINTED FOR PRIVATE CIRCULATION.)

JULY 1857.

PREFATORY NOTE.

At the request of some friends, I last spring delivered a lecture on Switzerland, at Chorleywood, in Hertfordshire, and repeated it to a London audience. In the idea that some of my friends and hearers might like to possess the lecture, I have printed it for their perusal, with considerable additions. I must, however, confess that the pleasure of preparing my lecture for the press, and the stimulus thus given to me to study the subject more fully, contributed not a little to decide me to print it. I have especially laboured at the account of the Glaciers, as I wished to present to the reader all facts and theories connected with this subject which could be presented in a popular and somewhat picturesque form, so as in fact to produce a short

manual to remind any of my readers who might visit Switzerland of what they should observe. I have ventured to put forward some ideas connected with the various glacial theories, which may possibly help, to some slight extent, to promote an understanding of this interesting subject.

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LECTURE ON SWITZERLAND.

PART I.

GENERAL CHARACTER. — SNOW. — GLACIERS.

LADIES AND GENTLEMEN,

At the request of Mr. Spottiswoode, I propose to repeat to you this evening a lecture which I lately delivered at Chorleywood, but I feel considerable diffidence as to my success. The audience whom I addressed in the country, was composed principally of agricultural labourers; but on the present occasion, my hearers consist of persons, not only living in London, the very atmosphere of which seems saturated with knowledge, but persons whose whole existence is associated with literature. It is, therefore, not without reason that I feel diffident in addressing such an audience, and

on a subject apparently so trite as Switzerland. I shall, however, do my best to entertain you; I hope also to instruct you, and, it may be, to enlarge your views, and elevate your minds. But I must beg you to recollect that my audience is composed of different classes, and it is my wish, that what I say should be intelligible and interesting to those among you who know the least; my friends will, therefore, I hope, judge me, not by their own standard, but by that of the least instructed of my hearers.

One of my principal objects will be, to try to awaken in you a love of the beauties and sublimities of nature, and a wish to understand her laws. I am convinced there is nothing so conducive to happiness as the possession of a mind capable of feeling, of deeply appreciating, the glories of external nature, whether displayed in the sublimity of a snow-covered mountain, or in the rich verdure of the flowery plain; whether manifested in the impetuous power of the dashing torrent, or in the still beauties of the peaceful lake; whether it is felt in the solemn silence of the starlit heavens, or in the gorgeousness of glowing sunshine; whether in the calm stillness of "dewy eve," or in the hopefulness of "incense breathing morn." It is delightful to possess a mind sus-

ceptible of these feelings, but it is better still if, in addition to the power of deeply enjoying the beauty, we are also capable and desirous of understanding the laws, of nature. I cannot imagine a man who has had means for passing a happier life than Humboldt, — a man who, keenly alive to the beauties of nature, and prepared with a knowledge of every science, had the opportunity of visiting the grandest scenes of nature, where every glory and every grandeur awakened in his mind a responsive chord, and where every object that met his view spoke in tones intelligible to him, but which to a less instructed mind would have been as the dumb speaking to the deaf. Nature, indeed, is like a musical instrument, which, to him who understands it, gives forth enchanting harmony; but, to him who does not understand, it is a complicated puzzle without a meaning and without a sound. A mind such as Humboldt's has fallen to the lot of few; but if in your minds I can raise one spark of that fire which illuminated his, if I can show you how much this earth gives us to love and delight in, and if I can convince you that knowledge enables us to love and worship with keener zest, I shall not have lectured in vain. When I went to Switzerland I deeply felt and enjoyed the glories of all I saw, but were I to repeat my visit, I believe

I should enjoy everything even more, because I should understand more: and I repeat, that what I especially wish to impress on you is, that it is this union of knowledge and of what I may call poetical feeling, that, as I believe, renders the mind capable of enjoying the greatest happiness this world affords. There are but few of us, who have many opportunities for the exercise of these feelings in the highest degree (such as by a visit to Switzerland); but we all of us have occasional opportunities of enjoying them in a minor degree, and thus of keeping alive within us that frame of mind which receives pleasure from all natural objects.

It is now, however, high time that I should turn to the business of the evening.

Switzerland, as you all know, is situated nearly in the centre of Europe. It is about 200 miles long by about 150 broad, and it is therefore, about one fourth of the size of England and Wales, or about two and a half that of Yorkshire. Two thirds of its surface are covered with mountains, and the other one third consists of an elevated plain about 1300 feet above the level of the sea. Switzerland contains about 15,000 square miles, of which at least 1000 square miles are covered with everlasting ice and snow. I do not mean to say that there is an uninterrupted tract of

country of 1000 square miles covered perpetually with ice and snow; but there are perhaps ten miles here, and twenty or fifty miles there, covered with ice and snow, and if these were all joined together they would occupy a surface of at least 1000 square miles. Now probably this statement will not convey to your minds a definite idea of extent, and I will, therefore, endeavour to bring home to you what is meant by 1000 square miles, by telling you what extent of country in England would be comprised within this space of 1000 square miles. 1000 square miles is an area of 33 miles long by 33 broad, or as far as from West Drayton, on the west, to Purfleet, on the east, and from Broxbourne in Hertfordshire, on the north, nearly to Reigate, on the south. It is in fact as if the whole of Middlesex, one fourth of Surrey, part of Hertfordshire, part of Essex, and part of Kent, were covered with everlasting ice and snow.

Two thirds of the surface of Switzerland are, as I have stated, covered with mountains, and it is this that gives the country its greatest charm; it is this that sends thousands of English as well as other nations every year to enjoy its beauties, to climb its rugged rocks, to wander among its valleys, and to return home with minds and bodies invigorated and refreshed.

I will endeavour to describe to you the feelings that arise in a man's mind when he approaches a snow-covered mountain for the first time. We will suppose him to approach it along a level plain, and on a cloudy, changeable day. Well! he travels on, anxiously looking out for the mountain; he searches for it high and low, when at last the clouds begin to break and he sees one cloud, as he thinks, that looks whiter and brighter than the rest. He says, in his mind, "Can that be the mountain?" but no, it cannot be, it is so high, it is in the very heavens. But somehow he cannot take his eyes off it, he sees it does not move, the clouds gradually clear away, the mountain at length stands revealed in all its majesty, and with a cry of wonder, he exclaims, "That *is* the mountain." I have seen mountains under these circumstances, but without seeing them it is hardly possible to feel how great and glorious they are. Feelings of the power and greatness of the Creator, rise spontaneously in the mind; all the daily troubles and petty vexations of life are forgotten; all the shortcomings and feelings of crushed and disappointed aspirations are wiped away; even all the daily sources of joy and happiness are forgotten, all is swallowed up in the intense delight of the present hour; and for ever to contemplate the glorious

scene seems to be the only happiness worthy of existence.

It is worth going to Switzerland to have these ideas excited in one's mind. There are beautiful mountains in this country, in Wales, in Scotland, but even in size they are not to be compared with the Swiss mountains. Ben Nevis, the highest mountain in Great Britain, is between 4000 and 5000 feet high, and Mont Blanc is nearly 16,000 or almost four times as high. St. Paul's Cathedral is 400 feet high, and it would therefore take nearly forty cathedrals of the height of St. Paul's, piled one on the top of another, to make a mountain as high as Mont Blanc. But it is not the size alone of the mountains that gives them charms, that makes you love and worship them; it is their form, the awful precipices, the deep ravines, the play of light and shade on their sides, and above all it is the everlasting snow that invests them with such inexhaustible attractions.

The snow on the mountains is more beautiful than the snow in this country. It is cleaner, whiter, and brighter, especially as you ascend to great elevations. On the lofty summits the snow is more highly crystallised, and consequently it reflects the light much more brilliantly. It is quite dazzling, and if a traveller is walking for some hours on the snow on the

lofty mountains, it is quite necessary to wear spectacles, or some protection for the eyes. Even the guides adopt this precaution. I suffered severely from neglecting it. I crossed a pass called "The Tschingel Pass," and was on the snow for some hours. I had with me a pair of spectacles made of wire gauze, which are the best, and I put them on for a short time. I found them, however, disagreeable, and not having patience to get accustomed to them, I took them off and put on a green veil. This I found hot, and therefore wore it only on one side. The result was, that when I went to bed at night, I had a violent inflammation of the eyes, and thus learned a lesson about snow travelling which I am not likely to forget.

Among the charms of the mountains must not be forgotten the beautiful colour of the sky. I do not know whether the purity of the atmosphere gives it a deeper hue, or whether it is the contrast between the dazzling snow and the blue sky that produces the effect; but, whatever the cause, it is certainly true, that the sky when seen from the lofty snow-covered mountains, appears of a deep purple, and indeed almost black colour. When a mountain is above 11,000 feet high, it is rare to find a spot uncovered with snow, except where the rocks are so

perpendicular that the snow cannot rest upon them, and these dark precipices contrasting with the unsullied snow and the purple sky add greatly to the beauty of the scene.

Above the height of 11,000 feet, rain never falls; moisture always descends in the shape of snow; and on the loftiest summits the snow does not fall, as it falls here, in great flakes, but it falls in the shape of a dry drizzling powder. I have talked of the everlasting snow. Now this expression is practically, but not literally correct, for the snow melts everywhere, but at great altitudes it melts only to a small extent, and there is therefore a constant accumulation of snow, which in some places becomes extremely deep. The snow does not, however, go on increasing in depth from year to year, and the explanations I now propose to give you of the cause of this, will I hope make you acquainted with all the mysteries and wonders of the Alpine ice and snow.

In the first place, the air on the tops of the mountains is very dry, and consequently there is a great deal of evaporation, which wastes the snow; then again, the wind rages with great violence on the lofty summits; it blows with a fury unknown on the plains, and the snow is thus swept away and scattered, or deposited in the valleys. But the most

powerful agent in removing the snow is the avalanche. Most of you know what avalanches are, but it will probably interest you to hear something about them.

An avalanche is a mass of snow which falls down the mountains with a noise like thunder, scattering death and destruction all around. It is very beautiful to see avalanches at a distance. They look like graceful waterfalls descending in white foam and silvery spray, and apparently so gently, that you wonder what can cause the awful sound. If, however, you were near, you would cease to wonder, for thousands of tons thus fall at once. Forests are cut through, and great trees broken off short, as if a gigantic mower had been busy with his scythe; houses and villages are buried, and the inhabitants suffocated almost before they know what has happened to them. Then again, the avalanche is accompanied by a violent rushing wind. The vacuum created by the snow torrent, is instantly filled by the rush of air, which produces a perfect hurricane. Houses are unroofed, haystacks sent whirling through the air, and trees torn up by the roots. In particular states of the snow and atmosphere, and where the snow hangs on a steep mountain, a very slight concussion of the air is sufficient to bring

down an avalanche; and indeed the guides sometimes caution travellers against even speaking in such situations. As Byron says—

> "Ye toppling crags of ice!
> Ye avalanches! whom a breath draws down
> In mountainous o'erwhelming."

You can therefore easily imagine how the concussion of the air, produced by one avalanche, sets another going; and thus, with increasing power and noise, they rush into the valleys, where at length, after their wild fantastic dance, they lie still and dead, and all is silent as the grave.

The peasants have many ways of protecting their houses from these agents of destruction. The places where avalanches fall, are generally well known, and it is extraordinary that such places should not be avoided for habitations, but this is not the case; pegs, however, are often driven into the ground, which hold the snow together, and thus prevent it sliding down and forming an avalanche. In some places a slope of snow is built against the house or barn, and water poured over it, which freezes, and thus forms a powerful barrier against the snow torrent.

The great avalanches fall in the spring, when the sun begins to undermine the foundations on

which the snow rests, but smaller avalanches fall all the year. In some places, such as the steep sides of the Jungfrau, as seen from the Wengern Alp, avalanches are falling every few minutes.

There are ice avalanches as well as snow avalanches, and these are the most destructive. A few years ago, a great glacier fell from the mountains in the valley of St. Niklaus, near Zermatt. A village was destroyed, and it was some years before the hay fields were cleared of the great masses of rock brought down by the avalanche. But the most remarkable effect was that produced by the wind which accompanied the fall; and singularly enough, it was not the direct wind which produced this effect, but the reverberation of the wind from the opposite side of the valley. You can now easily understand what a powerful workman is the avalanche in helping to get rid of the snow. But the avalanche only moves it down, — we have still to get rid of it.

My next workman is a wind called the Fön — a hot dry wind which has its birthplace in the sandy deserts of Africa. So powerful is this wind that the inhabitants say, "The Good God and the Golden Sun can do nothing with the snow, if the Fön does not come." Indeed, without this wind, it is probable that three fourths of Switzerland would be an utterly desert land of glacier. When the Fön begins to

blow, the air is so deprived of its moisture, that man and beast are languid and enervated. The cattle drag themselves wearily about, and not a bird is to be seen on tree or spray. Such is the dryness of the air, that a spark would set on fire the wooden châlets, and the inhabitants therefore take every precaution against such a catastrophe. Watchmen go about to see that every fire and light is put out, that not a spark is left burning. The Fön wind acts with such rapidity, that three feet of snow is sometimes melted in twenty-four hours; but the Fön is a most judicious melter of the snow, it evaporates as well as melts, and thus the inundations, which would otherwise follow the rapid melting, are prevented.

After the Fön come the mild warm rains; all traces of the snow are washed away — the earth is softened — the grass and the flowers spring up and blossom — the seasons all follow in their appointed order, and universal harmony prevails. It is impossible, in all this, not to see the hand of an allwise Creator, who has preordained these things, and impressed on all creation immutable laws which must be obeyed, and, without the invariable action of which, instead of universal harmony prevailing everywhere, all would be ruin. The ice and the snow, the wind and the rain, all obey his voice, and one may imagine that they all respond to that eloquent

hymn of praise, "Oh ye frost and cold, oh ye ice and snow, praise ye the Lord; bless him, and magnify his name for ever."

I must now go on to the next great and strong workman — the glacier, without whose assistance the lofty mountains and high valleys would for ever remain an unyielding mass of everlasting ice. Now, bearing in mind that I have promised to explain everything to the best of my power, I must first tell you what a glacier is; and then, the history of the action of the glacier in removing the ice and snow, will give me the means of explaining to you all its mysteries and all its charms.

A glacier is a mass of ice, formed from snow. Its origin is at the summits of the mountains, from which it descends, filling the lofty valleys, and flowing down the steep sides of the mountains into the lower valleys, where it forms rivers of ice, and seas of ice. Throughout its course, until it arrives below the line of perpetual snow, it is fed by the snow which either falls directly on its surface or is precipitated thereon from the mountains at the sides of the glacier.

Now, I must first tell you how (according to some authorities) the snow gets turned into ice, and this, apparently, happens in two ways. First, as I have told you, the surface of the snow melts a little, and the water trickles down into the mass of

snow. At night this freezes, and turns a portion of the mass into ice. The next day a somewhat similar process goes on, and so the ice increases. But it increases also in another way, and that is by weight and pressure. The weight of ice and snow on the surface and upper portion of the mass presses down on the lower portion, and gradually squeezes it into a loose sort of ice called nevé, which, by further pressure, percolation of water, and freezing, becomes turned into glacier ice. You may see the action of this process, by trying an experiment for yourselves in the winter season. If you fill a pail with snow, and beat it with a heavy mallet, you will find that at the bottom it gradually becomes consolidated into ice.

This mode of accounting for the original formation of ice on the tops of the mountains, does not appear to me completely satisfactory, for the freezing would not penetrate deeply into the body of the snow, the pressure would act only after a certain depth, and there would be an intermediate space of snow left, which is not the case. To account for the presence of ice on the summits of the high mountains, we must go back to the time when they were bare of snow, thence to the time when snow first began to cover them, which, from the daily alternation of thawing and freezing, became converted into ice, and thus formed a nucleus for

future accumulation. Be this, however, as it may, it is enough for our present purpose to know that the snow does get turned into ice.

If you take a piece of ice two or three feet long, a foot broad, and two or three inches thick, into your hands, you will find it is tolerably heavy. A cubic foot of ice, that is, a piece of ice a foot long, a foot wide, and a foot thick, weighs about half a cwt. Now, if you recollect this, you can easily imagine what an immense weight the mass of ice on the steep side of a mountain must be. Many glaciers are ten miles long, two or three miles wide, and hundreds of feet thick; but, to give you an idea of the weight of ice on the side of a mountain, I will suppose a glacier half a mile long, a quarter of a mile wide, and twenty feet thick. Now, the weight of this mass would be about 1,800,000 tons. It is difficult for you to realise this weight, and I will, therefore, try to enable you to understand it by a comparison. Suppose I had a sufficient number of cubic yards of iron, that is, masses of iron measuring a yard every way, to weigh 1,800,000 tons. If I were to place them in a line, side by side, they would reach nearly 180 miles. This will enable you to realise the weight of the ice resting on the side of the mountain.

Now, you must recollect that at its origin and in many other places, the glacier rests on the steep side

of the mountain, and, consequently, it must always be pressing and sliding down, or trying to press and slide down.

"The glacier's cold and restless mass
Moves onward day by day."

The heavy mass of ice keeps pressing and squeezing forward, and pushing the ice into the wide valleys, where it spreads out, and forms great seas of ice; it is still, however, in its turn, unrelentingly pushed forward by the heavy ice sliding down the mountain, and it is thus forced through narrow valleys where it forms rivers of ice; and over precipices where it forms great waterfalls of ice, and finally it finds its way down to the valleys among the corn and flowers and fruit trees, where it lies dead. Here, however, it suddenly springs into new life. It melts and forms a river, which now glides peacefully among green meadows, now rushes along in a turbulent course among rocks and opposing obstacles, and at length joins the boundless ocean, where its separate existence is lost for ever. This completes my explanation of the way in which the action of a glacier is instrumental in carrying away the ice and snow.

I must now tell you more minutely about the glaciers. I have compared them to frozen seas and rivers, but you must not imagine that they are

covered with smooth ice, like the ice on a pond. The ice is sufficiently smooth and slippery to require sharp nails or screws in your boots; but still there is a considerable roughness on the surface, so that if you slip and fall, and save yourself on your hands, you cut them as if you fell on rough gravel.

There is nothing so exhilarating as walking on a glacier; everything is strange, everything is beautiful; the air is bracing, and the spirit of adventure is aroused. The colour is as beautiful as the sky, the forms are of infinite variety, the phenomena surrounding you on all sides are entirely new, and the dreams of fairy-land alone can equal the scene.

When walking on a glacier, you constantly meet with slits or cracks, which are sometimes not above an inch wide and sometimes forty or fifty feet; they are often very deep, frequently descending to the bottom of the glacier,—a depth sometimes of 700 or 800 feet. These are called crevasses, and the danger of glacier walking arises from their occurrence. If your foot should slip while walking along a narrow ledge or steep hill of ice, bounded on each side by a crevasse, nothing could save you from falling into the abyss, and your chance of escaping with your life would be small indeed.

It is extraordinary how few accidents, however,

do occur; the nerves are braced up, timid persons either soon retreat, or are well taken care of by the guides. There is but little danger except from fear. But accidents do sometimes occur.

There is a well-known story of a Swiss clergyman who was walking on the lower Grindelwald glacier with a guide, and who fell into a crevasse and was killed. When the guide, whose character did not stand very high, returned without the traveller, and said that he had met with his death in the way I have mentioned, it was suspected that the guide had murdered and robbed him. Accordingly a search was made for the body, and for some days the search was in vain. A man was let down with a rope into the crevasses, with a lantern tied round his neck, for it is quite dark in the depths of the ice. He had frequently to be drawn to the surface for fresh air, for the closeness of the atmosphere in the crevasses nearly suffocated him. At last he brought up the body with him, and the clergyman's money and his watch were found safe in his pockets. The guide's character was, therefore, cleared, and the truth of his story was established. He said that the clergyman was gazing into a deep crevasse, and, in order to get a better view of the magical beauty of the ice, he had planted his alpenstock on the opposite

side of the crevasse, and was leaning on it, thus hanging over the abyss. His alpenstock suddenly slipped, and the unfortunate man was precipitated into the crevasse.

Stories are told of almost miraculous escapes under similar circumstances. A solitary chamois hunter was crossing a glacier, when he was overtaken by a fog. He suddenly came to the steep side of a crevasse, his foot slipped, and he fell. Wonderful to relate he reached the bottom without breaking a bone. There are often hollow channels under a glacier, caused by the action of streams, and the melting of the under surface of the glacier. He crawled along one of these, which happened to be dry, in darkness; at length he reached the light of day and escaped.

Now I have told you that accidents rarely happen on glaciers, except from fear. There are, however, sources of danger which no courage can surmount, and which can only be overcome, and that not always, by skill and experience. Sometimes the crevasses are hidden, and the glacier itself entirely covered with snow. Under such circumstances there is great danger of falling into the crevasses, as the snow is apt to give way under the weight of a man. On one occasion a guide, with whom I and a

friend, also accompanied by a guide, were travelling, had a narrow escape from this cause. We were crossing the Tschingel glacier, which was covered with about four feet of snow, and the crevasses were consequently hidden. Suddenly, down went the guide into a crevasse. He fortunately fell in only up to his shoulders: but he never could have extricated himself. We immediately came to his assistance and pulled him out. The precautions used on such occasions are—first of all, the whole party are tied together with a rope, and, if there are three or four persons, it is very unlikely that a serious accident will happen; and next, the leading guide always probes the snow very carefully with his alpenstock, and, if he does not find a solid bottom he immediately stops.

These crevasses, especially those which are narrow, are often filled with water, which is always of the most perfect clearness, and the most lovely blue colour. There are often, also, miniature ponds and lakes scattered over the surface of the glacier, with the most beautiful ice crystals at the sides looking like sea-anemones, and lovely marine plants. Then, deep below, you hear the rushing of the streams, hundreds of feet beneath you, at the bottom of the glacier. The surface too of the glacier is

covered with little streams, sometimes mere rills, sometimes rushing brooks, and sometimes almost rivers, running through banks of ice, and making waterfalls over ice precipices. These streams always, at last, empty themselves into a crevasse, or a deep hole, where it forms what is called a *moulin*, or mill pool, from the extraordinary rushing sound the water makes. But if you wait till night, the whole scene changes; first one little stream freezes and then another, till at last, except on those glaciers where there are large streams, all is perfectly still and silent. The change from universal motion, and continual rushing of water, to stillness and silence is very striking.

The next glacier wonders are the ice-caves. These are of the most magical fairy-like beauty. I have walked in these caves with an ice roof above me, an ice floor under my feet, and ice walls on each side of me. The ice was so transparent that I could see at least a yard into its substance; so smooth and polished, that the hand could trace no roughness; so brilliant, that the ice almost formed a looking-glass; and all was of the most beautiful blue colour. This lovely colour appears to be an inherent property of the ice, and not to be derived from reflection from the sky, for the ice is equally blue on a cloudy as on a

bright day. It sometimes happens that a river rises in the upper part of a glacier, and that from the direction of the glacier, it first runs by its side, and then from a sudden turn flows into it. Under these circumstances a beautiful ice-cavern is formed. I have seen the Rhone thus flow under the glacier, forming a fine waterfall as it rushed into the glacier. It was concealed by the ice for above a mile, and then rushed out of a similar blue ice-cavern at the other end.

There are ice-caverns of a different character in the *nevé*. This term, which I have already used, is the name given to the snow when it is passing into the state of glacier ice. The *nevé*, or *firn*, as it is called by the Germans, is of a less compact texture than the glacier ice, and is therefore more easily thawed and acted on by water. Consequently great caverns are formed in it, more like the stalactitic caverns in various rocks, but in one respect they are much more beautiful: for instead of their being lighted by a few torches or candles, they are illuminated by the light which passes through their very walls, and which thus acquires a beautiful greenish hue. The colour of the *nevé* is rather green than blue. These caverns are filled with great blocks of ice, and from the roof hang great icicles, like stalactites, from ten

to twenty feet long. The icebergs in the Arctic Ocean are usually formed of *nevé* or congealed snow. They are sometimes met with formed of ice, and these are much more dangerous.

The nevé consists of alternate layers of granular snow and hard ice. This structure is supposed to arise from the melting and freezing of the annual fall of snow.

I must now endeavour to explain to you the motion of a glacier, and this will give me an opportunity of describing the other wonderful phenomena connected therewith. The first point will be to prove to you that the glacier does actually move. There are blocks of stone, and great fragments of rock lying at the side of almost every glacier, which form what is called the moraine. On each side of the glacier there is a line of rocks forming "lateral moraines." There is also frequently a "central moraine," arising from the uniting of two glaciers into one, and the mingling at the point of junction of the right moraine of one, and the left moraine of the other, into a single moraine, which is necessarily a "central moraine." At the termination of the glacier, there is a great mound of these rocks, forming what is called the "terminal moraine." Now let us first consider how this terminal moraine has got

there. It is frequently the case that, at the termination of a glacier, there are no high rocks on each side from which the fragments composing the moraine can have fallen. A man observing a glacier for the first time would consequently be puzzled to account for the origin of the heap of rocks, but, if he ascended the glacier, he would notice a continuous line of rocks along the side of the glacier forming the "lateral moraine," and he would conclude that this line or stream of rocks must have something to do with the heap of rocks at the end of the glacier. Now we will suppose he continued his journey up the glacier till he arrived at a point where the glacier was bounded by precipices. On examining them he sees they are limestone. He looks at the moraine, and sees that the fragments are principally granite; he knows there is no granite within many miles higher up the glacier. He then says, these granite blocks must have come from the granite rocks higher up the glacier. He then reflects a little, and it occurs to him that if fragments kept falling from a rock on to the ice, the fragments of rock would extend across the glacier and block it up, instead of forming a mere fringe on the side. All at once it flashes across him, "This would take place if the ice was stationary; but suppose the ice moved, it would

then all be perfectly plain and intelligible." He is thus forced to the conclusion that the ice moves, and carries the blocks of stone along with it.

The movement of the glacier has, however, been made the subject of actual demonstration. The position of a mass of rock on the glacier has been taken at different times, and it has been found to have moved down the glacier. Again, the fragments of a hut which was erected by Hugi on a glacier, were found some years afterwards a great distance lower down the glacier.

Experiments have also been tried, to show at what rate the glacier moves, and it is found that the average rate of motion of a glacier may be taken at about a foot a day. The centre moves faster than the sides, the surface faster than the bottom, and the glacier moves faster in summer than in winter. It is also found that warm damp weather quickens the motion. It is therefore quite clear that the glacier moves, and we must now try to find out what makes it move.

There are several theories to account for the motion, but it appears to me that the explanation I have already given you, viz. that it moves by gravitation or weight, is the most correct. I have proved

to you the enormous weight of the glacier, and we know that at its origin it rests on a very steep basis. We also know that the surface on which the glacier rests must be very smooth. There may be, and no doubt there are, occasional inequalities of surface, impeding rocks and so on; but the surface of the rock, and of every obstacle opposing the passage of the ice must be very smooth. What is the evidence of a glacier retreating? Why, the polished surface of the rock in its front. Surely then, if a surface which must have been only a comparatively short time subjected to glacial action, is smooth and polished, the main bed of the glacier which must have been a much longer period under such action must be polished and smooth. Again, there is some ground for believing that the surface of the earth under the glacier is generally, if not always, sufficiently warm to keep the ice in a melting state. Further still, we know that in many cases, the glacier rests on a bed of broken rock or gravel, which it has brought down with it, and which soon becomes a mere powder in the form of mud.

I may remark, in passing, that it is this powder or mud which renders a glacier stream so thick and turbid. The streams on the surface of a glacier, are, as I have already mentioned, beautifully clear, pure,

and bright, but the stream issuing from the foot of the glacier, is, from the mud brought down, and from the continued grinding action of the glacier on the rocks, thick, turbid and full of mineral matter.

I will now recapitulate the facts I have mentioned. We have a mass of ice of immense weight, resting on a steep slope, the bottom of the ice being in a semi-fluid state, the bed on which it rests being either polished rock without anything intervening between the ice and the polished surface, or with an intermediate layer of gravel, which soon becomes degraded into mud. It seems to me that ice, under such circumstances, must move by its own weight.

The objection to this theory is, that in many places the glacier is nearly flat, that in such places it descends at no greater angle than two or three degrees; and that, consequently, at such an angle, gravitation would not force the ice forward. But we must not forget that, even where the glacier slopes only to a slight extent, there is an enormous mass behind, which is always growing, always moving, always pushing, and squeezing forward; and it appears to me, therefore, that this enormous moving weight acting on *so peculiar a body as ice*, must drive it forward.

There have been two other theories to account for

the motion. One is, that inasmuch as we know that the ice is full of small cracks, or miniature crevasses, which are filled with water, the water contained in these little crevasses, must be continually freezing and thawing, and consequently expanding and contracting. It is, then, further supposed that this action drives the whole mass of the glacier forward. I cannot myself conceive that, even if we grant the facts, sufficient power to move the glacier would thus be obtained. But the facts are not admitted. The daily change of temperature does not penetrate beyond a few inches below the surface.

A similar theory has been put forward by the Rev. Canon Moseley, also resting on alternate expansion and contraction. Mr. Moseley had observed that the lead on the roof of Bristol Cathedral, lying at an extremely small angle, was drawn down and puckered up at the bottom, and that nails inserted at the upper portion to hold it up, had been drawn out. Now the angle at which the lead rested on the roof was too small to allow the lead to descend by its own weight. It occurred therefore to Mr. Moseley that the motion of the lead would be accounted for by alternate contraction and expansion, acting in the way I will now describe to you. Suppose two cubes of

any substance, lying on a flat surface, were connected together by a spring, and that the two cubes were pressed close together. On removal of the pressure, the spring would drive the cubes in opposite directions. Now suppose these cubes were placed on an inclined instead of a level surface; the spring would drive the lower cube down, but would not drive the upper cube up. If the two cubes were now re-united by a contracting spring, the lower cube would not be pulled up, but the upper cube would be pulled down, and if this action was repeated, the cubes would progressively move forward.

There is no substance, it was argued by Mr. Moseley, that expands and contracts more than ice, and it may be, for the purpose of this argument, considered as a body formed of cubes connected by springs as I have described. This theory, like the former, rests on the supposed expansion and contraction of the great body of the glacier, and if, as I believe, this expansion and contraction penetrates only to a very small distance into the body of the ice, the theory breaks down.

I have described ice as a peculiar body. We usually look on ice as a hard brittle substance, that can certainly bend to some extent, but that would break to pieces if any attempt was made to squeeze

it through a contracted channel. Professor Forbes, however, tells us it is more like glue, and he therefore describes it as being what he calls viscous. Now, whether this theory be right or wrong, and whether, which we will presently examine, the term *viscous* be appropriate, there is much to be said in its favour, and if it be viscous, it is more easy to understand the motion of a glacier than if it were hard and brittle. If the ice forming a glacier were hard, brittle, and unyielding, the glacier would always descend in avalanches. The ice would resist the pressure from behind till it became too strong; the barrier would then suddenly give way, and down would rush the ice, in great masses, one heaped above the other in wild confusion, till a mountain of ice fragments was heaped up, leaving space behind it for further accumulations of the unrelenting enemy that after a time was again to repeat the catastrophe. Now we do not find this to be the mode of action. Down a steep precipice, the ice descends, riven into great crevasses, torn to pieces, and piled up in picturesque masses. But no sooner has the glacier escaped from the horrors of the destructive precipice, than it again resumes its comparatively peaceful course.

Again, several tributary glacier streams (the rivers

of the ice-realm) frequently unite in one ice-sea, the escaping stream from which is smaller than any one of the tributary streams, and yet the whole mass passes through this narrow channel. It passes, as I have said, through this narrow channel, and then expands again into a wide flat ice-sea on the other side. Unless ice possessed a power of bending and altering its shape without fracture, I think that this re-expansion in a flat form could not take place. Glaciers also frequently lap round corners in a way that gives one an idea of viscosity. The whole motion of a glacier resembles that of a fluid. It moves faster at the centre than at the sides, and it is believed that it also moves faster at the surface than at the bottom. If a row of sticks is placed in a straight line on a glacier, the line soon becomes curved into a semicircle, because the centre moves faster than the sides.

Before I pass on to another theory of the nature of ice, let me call to your minds the fact that ice is elastic. When a pond is thinly frozen over, just strong enough to bear, we know that the ice will sway up and down to a considerable extent; that is, that it will bend without breaking. Now, let me call to your mind a similar property of timber. If you take a great beam of timber, support it on its

two ends, and then place a heavy weight on it, the timber bends; when the weight is removed, the timber springs up again. Now, if a weight, sufficient to bend the timber just within the extent at which fracture would take place, is suffered to rest on the beam for a certain time, the timber will remain bent when the weight is withdrawn. If, after this, the timber is allowed to repose for a time, and then a greater weight is placed upon it, the timber will bend to a greater extent, and this process may be repeated over and over again, till the timber is bent into a semicircle. Now, we know that the power acting on the ice, viz., its own weight, is greater beyond comparison than any artificial weight we can collect; and we know that this power acts more slowly and continuously than any human invention can contrive. We know, also, that ice is elastic; that it can bend to a great extent without breaking. It therefore appears to me, that ice acted on by an almost infinite power, for an almost infinite space of time, may change its shape to an indefinite extent without breaking, and that, consequently, whether the property which enables it to do so, is called viscosity or anything else, this property helps to account for the passage of ice through narrow channels without frac-

ture, and for its re-expansion after such a passage, also without fracture.

The other theory of the nature of the ice, and of the manner in which it moves, may be called the regelation theory. Professor Tyndall, the author of this theory, could not bring his mind to believe that ice possessed a property so contrary to the generally received ideas relative to the nature of ice as viscosity, and it appeared to him that all of Professor Forbes' facts might be accounted for by the theory, that the ice was broken to pieces and frozen again. It is known that fragments of ice, when placed together under the, apparently, most unfavourable circumstances, will freeze together into a solid mass. Pieces of Wenham lake ice, heaped up together on a hot summer's day, in a shop window in the Strand, freeze into a solid mass. Two pieces of ice placed together even in very hot water freeze together. Professor Tyndall also froze fragments of ice together, under other circumstances, into a solid mass. Professor Forbes bent bars of ice into circles and other forms without the ice losing its transparency, and consequently, as he believed, without fracture. Professor Tyndall took broken fragments of ice, compressed them in a mould and brought them out compact masses of transparent ice. Now this

proves that regelation into a solid mass may, and no doubt constantly does, take place; but it does not, it seems to me, prove that ice cannot be bent without fracture and regelation. I have myself no doubt that there is a great amount of truth in the regelation theory, and that fracture and regelation are continually taking place; but it appears to me that the regelation theory, if understood in the way I have explained it, fails to account for the re-expansion of the glacier into a wide flat ice-sea after its passage through a narrow channel.

To sum up again. I believe that the glacier descends from its origin in the nevé by its own weight, the surface on which it rests being smooth, and the under surface of the glacier being in a semi-fluid state; that the same power and the same conditions are the cause of its continued motion; that the viscosity or elasticity of the ice enables it, when acted on by an enormous weight, to pass through contracted channels, and to re-expand itself. But I also believe that, throughout its entire route, inequalities of the ground, sudden descents, contracted channels, and other causes, often break the ice into fragments, and that they are again frozen together into a solid mass. I believe also that expansion and contraction are continually taking place,

and that this may to a small extent assist the motion. With regard to crevasses, I do not think their origin is well explained, but apparently they are partly caused by the descent of ice over sudden inclines, and that the presence of crevasses in particular spots is thus accounted for. I think that diurnal expansion and contraction are also a cause of crevasses, and a cause of their increase, and I believe that the crevasses are healed up by regelation.

Before I quit this part of the subject, I will endeavour to put it before you in another point of view, partly with the object of giving you a fuller comprehension of all its various features, and partly also with the hope of suggesting what may possibly promote the establishment of a sound theory.

From the phenomena exhibited, it appears that the glacier must be considered as an imperfect fluid. Whether the term viscous fluid is a proper term is not the question. The main question is, can a glacier be called a fluid? The first and best answer is, it moves as a fluid moves. Now there are many kinds of fluids: air is a fluid, water is a fluid, and mercury is considered to be the most perfect fluid. Treacle, glue, tar, lava, and even pitch, are fluids, and may be termed viscous fluids. Wet mud must be described as a fluid, and even dry sand is considered a fluid, although I think it must be admitted to be a very imperfect one.

It seems to me that the fluidity of ice is not exactly like any of these different kinds of fluidity, but I think its mode of motion may be explained by a known principle, which has, I think, been overlooked. I must first state that the regelation theory, as put forward, appears to suppose a complete fracture of the ice, a breaking of the ice "into a thousand fragments" (as expressed by its able advocate), such a fracture in fact into *irregular particles* as would (without the action of the principle I am about to bring forward) necessarily destroy transparency, until the ice was frozen again. Now, in my opinion, there is a mode of fracture and regelation which would not cause a cessation of transparency, and which would reconcile the two theories of viscosity and regelation.

It is well known that pressure, combined with friction, developes heat, and it is admitted both by Professor Forbes and by Professor Tyndall, that both pressure and friction are the necessary accompaniments of glacial motion; and that, in fact, pressure and friction are the cause of that structure, called the blue-vein structure, which I shall presently describe. It has also been ascertained that the glacier ice is always at a temperature of 31° or 32°, in other words, close on the melting point. Now

it seems to me that a development of heat throughout the mass of ice would cause an universal, but very slight, melting*, which would permit a bar of ice in a mould to adapt itself to its prison without loss of transparency, would satisfactorily account for the transmutation of white honeycomb ice into the blue-veined structure, and would enable the glacier to adapt itself to the varying configuration of its bed. The ultimate particles of the ice, lubricated, if I may use such an expression, by the half-melting necessarily produced by the developed heat, would roll one over the other, any interstices being completely filled up by water and transparency thus preserved. When the pressure ceased, and we know that the amount of pressure must vary, the heat would no longer be developed, and regelation into a compact mass would take place.

I must now go on to some other peculiarities of glacial structure, in describing which I shall return to the theory I have ventured to put forward.

I refer to what is called the veined structure. It is only within the last twenty years that this has been observed; and I confess I did not notice it myself when I visited Switzerland. The greater portion of the glacier consists of non-transparent ice,

* Sir Humphry Davy caused two spheres of ice, *in vacuo*, to revolve and rub against each other. The friction caused them to melt.

of a whitish colour, and comparatively loose structure, which has been compared to a honeycomb; but throughout the mass are interspersed veins of blue transparent ice, of a hard, compact character. These blue veins vary in thickness from an inch or two to many feet; and when I spoke of the beauty of the ice caves, it was to ice of this character that I referred. The direction of these blue veins is not horizontal, but vertical, or nearly so; that is, they do not lie flat on, or in, the glacier, at varying depths, but run down from the surface, like a wedge driven down into the glacier. When traced into the interior of the glacier, it is found that they lean forward. It is also found that wherever the pressure is greatest, there this veined structure is most developed. For instance, at the junction of two glaciers, this structure is strongly developed. It is also found that glacier ice is what is called laminated, that is, that it has that kind of structure which is familiar to us in slate, viz., that it can be split into plates or laminæ. This character is particularly developed in the blue veins. Lastly, I must observe that this susceptibility of splitting, or cleaveability, is developed in a direction at right angles to the direction of pressure. It has been found that if a mass of clay, of wax, or even of butter, is subjected to great pressure, it is capable of

being split into plates like slate, and that the cleavage is at right angles to the direction in which the pressure is applied.* Hence it is inferred that this peculiarity in the ice is produced by pressure, and that the leaning forwards of the veined ice is produced by the onward motion of the glacier, which is believed to be faster at the surface than at the bottom. There is another theory of the formation of these blue veins, and that is, that they are crevasses filled with water in summer, and frozen in winter. It is doubtful whether this theory is based on observed facts, and it seems to me that as we have positive proof that pressure produces cleavability, and that pressure, combined with friction, developes heat, we thus have a satisfactory explanation of the transmutation of loose honeycomb ice, full of air, into compact transparent laminated ice. Pressure, on this theory, not only squeezes together, gets rid of the enclosed air, and produces the laminated structure, but also melts the ice, which when pressure is withdrawn, freezes again into a, necessarily, compact mass.

* The Rev. S. Haughton, M.A., of Trinity College, Dublin, has favoured me with some remarks on the analogy between the cleavage of rocks and the structure of glaciers, with especial application to the origin of crevasses. By his kind permission I have printed it as an appendix.

I have omitted to describe to you what are called glaciers of the second order. These are glaciers which hang on the sides of the mountains, and which, from the surface on which they rest being bounded by precipices, or being excessively steep, are not continued into the valleys. They seem to hang on the mountains like a great drop of gum, and from time to time, when the weight becomes so great as to overcome the cohesion of the ice, and the resistance of the surface on which the ice rests, they break off, and are hurled into the valleys in the form of great avalanches. I have described a catastrophe of this kind which occurred near Zermatt.*

The "dirt-bands" on the glaciers have recently attracted a great deal of attention. These bands are best seen when looking down on a glacier from a height. It is then seen that (when they occur) the glacier is covered with elliptical dirty marks separated from each other by clean intervals. I believe the explanation that these bands are accidental patches of dirt, occurring here and there, which are drawn out

* Lord Dufferin, in his "Letters from High Latitudes," describes a glacier of this kind. "On the left, a still more extraordinary sight presented itself. A kind of baby-glacier actually hung suspended halfway on the hill-side, like a tear in the act of rolling down the furrowed cheek of the mountain."—P. 300.

into an elliptical form by the motion of the glacier, is a true explanation. Professor Forbes, however, states that the dirt accumulates only on the uncompact ice, where it is retained by the comparatively rough surface. The fact requires more exact confirmation.

I must now resume my account of the more popular features of glacier life. On a glacier almost everything is contrary to what it seems, or to what you would expect. A small stone, or piece of thin slate sinks into the ice, but a large heavy mass of rock not only does not sink in, but even seems to rise above the glacier. If, in the month of March, you were to place on the glacier a mass of rock, of the size of an ordinary house, and a thin piece of slate, and were to re-visit them again in three months, you would find the mass of rock raised six or eight feet above the glacier on a pedestal, and the slate sunk deep in the ice. Now, there can be no doubt, that to a person unacquainted with glacial phenomena, this would be a very unexpected result. How does it happen? The mass of rock protects the ice under it from melting. There is an annual waste on the surface of about sixteen feet; the whole surface of the ice, therefore, melts, except where it is protected by the mass of rock, which thus, after a time, rests on a block of ice. This gradually thins into a pedestal, and the

rock thus forms an ice-table. The pedestal becomes thinner and thinner from exposure to the sun, till at length the pedestal becomes too thin to support the mass; it breaks; the rock falls on the ice, and the same process occurs over and over again. But how is it that the thin piece of slate sinks into the glacier? It is in this way. The slate is not thick enough to protect the ice, on which it lies, from the heat of the sun; but, on the contrary, the heat is radiated more quickly from the slate into the ice than elsewhere. The ice, consequently, melts faster under the slate, and the slate sinks in. In some places pieces of slate are collected, to spread over the snow in the spring, and thus expedite its melting. There is often under a large glacier table, a hollow basin surrounding the pedestal, produced by the reflection of heat from the under surface of the table, which causes the ice to melt more rapidly immediately under it.

It is worth considering how it happens, if there is an annual waste of sixteen feet on the surface, in addition to the waste below, that the glacier does not keep diminishing in thickness, which we know it does not. I think this may be accounted for by the greater rapidity of motion at the surface, combined with the semi-viscous nature of the ice which I have ascribed to it.

Sand heaps form another very striking phenomenon connected with glaciers. I have already mentioned that the surface of a glacier is covered with little rills or streams. These very often bring down sand and gravel from the moraines. In their course they meet with a hole formed in the glacier by a stone, or a piece of slate such as I have described. This gradually becomes filled with sand, and, immediately the process, which converted the rock into a glacier-table, begins to convert the funnel filled with sand into a great cone of ice coated over with sand. These cones are sometimes thirty feet high. The sand protects the ice under it. The ice surrounding the sand begins to melt, and consequently the sand rises above the glacier. Then the sand begins to slip down, and thus covers and protects a wider surface, till at last there is a great cone thinly covered over with sand and gravel.

A central moraine is a gigantic sham of the same kind. At a distance, you see on the glacier an enormous heap of rocks, fit for a rampart in a battle of Titans, forming the central moraine of the glacier. It looks like a solid mass of rocks, a huge heap of superhuman masonry. It is nothing of the kind. It is a mass of ice covered over with a coating of rock fragments. A little reflection shows it must

be so. Two lateral moraines meet, and form a central moraine in the middle of the glacier. The glacier carries the burden on its back in its downward course. But the burden repays its gigantic horse by protecting him from the consuming heat which wastes and kills him. The ice under the moraine does not melt; the moraine consequently gradually becomes raised up into an immense rampart, and then the ice-table process is repeated on an enlarged scale.

In describing a glacier, I must not omit to mention the danger arising from the avalanches of rock and stone which form the moraines. Fragments of rock, undermined by the rain, the frost, and the snow, are continually breaking off. Sometimes isolated masses bound from rock to rock, and at length fall with a crash like thunder on the glacier. At other times the fragments gradually accumulate, till at length the weight is too great to support itself, and down comes the whole mass with a noise like the discharge of artillery. I have seen and heard stone avalanches of this kind. The guides know where these avalanches are in the habit of falling, and cautiously avoid such places.

Some glaciers are annually increasing, and others retreating. It is believed by many of the Swiss

peasants that a glacier increases for a certain number of years, and then retreats for a certain time, but this belief does not appear to rest on a solid foundation. It is, however, quite certain that many glaciers are annually increasing. The Gorner glacier, and the Stein glacier, at the summit of the Susten pass, are examples of this. Others are retreating. It is easy to know whether a glacier is on the increase or on the decrease. If increasing, the ground is raised up in ridges in advance of the glacier, which is ploughing up the ground under the surface just as a plough raises up furrows in its progress. If, on the contrary, the glacier is retreating, there is in front of it, a bare polished surface of rock, devoid of flowers or herbage, and devoid even of soil. Where the glacier has placed its foot, like the old legends of the devil's hoof, a mark is left which it requires ages to efface.

Glaciers exist now, where, within two centuries, there was no trace of them, and where there were passes over which mercantile traffic was continually carried on. Over the Col du Géant, which is now one of the most difficult glacier passes, there was a pass constantly frequented by mule drivers, and the Protestants of the Haut Valais were in the habit of taking their children across what is now the great

glacier of Aletsch, to Grindelwald for baptism. At the same period, horses passed the Monte Moro from Saas into Italy.

On the other hand, there is abundant evidence to prove that glaciers of enormous extent existed formerly where no glaciers now exist. The whole valley of Chamouni is supposed on good evidence to have been once filled with glaciers. A glacier leaves behind it such unmistakeable traces, that, where you see its apparent footsteps, there you may feel sure that the glacier has been. Moraines are one of the marks of a glacier. In some places are found, on the sides of valleys, long lines of rocks and stones, sharp and angular, differing entirely from the rocks on which they lie, and removed many miles from similar rocks. Now, if these had been transported by water, they would have been rounded instead of angular. Again, these rocks and stones are found of all sizes, mixed together. Now water sorts stones into sizes. Small stones are moved more easily, and, therefore, faster than large rocks; consequently, the large and small stones are sorted. Now, this is not the case in these long lines of rocks, which are therefore supposed to be ancient moraines.

There is another evidence of glacial action, in the polished and striated rocks. I think I mentioned to

you that the glacier scratches and polishes the rocks as it passes along. The glacier carries with it gravel and fine sand. These act like emery on a potter's wheel. The gravel being pressed with great force against the rock, by degrees breaks off every projection, and, finally, with the assistance of gravel ground down to sand, quite polishes the surface. Occasionally, the passage of a sharper and harder piece of stone scratches the surface. Now, these scratches are always lengthways, thus showing clearly the direction in which the stream of gravel passed. Polished and scratched rocks, and blocks of rock resembling moraines, are found in many places where no glacier now exists, and where there is no tradition of a glacier having ever existed; but where, for these reasons, it is believed, glaciers were formerly found.

It was once supposed that the masses of rock to which I have alluded were transported by water. There is a remarkable angular rock of this kind called the Pierre à Bot, near Neuchâtel, which is supposed to have come from the Alps, on the other side of the Lake of Geneva. It was actually believed at one time, that this mass was washed down from its birthplace in the Alps, by a torrent, which gradually gave it such a velocity, that at length it bounded across the

lake of Geneva! Independently of the magnitude of the leap, one would think it should have excited wonder that such a mass fell, without breaking to pieces. In this country, both in Scotland and Wales, there are evident traces, such as I have described, of former glaciers. In the Vale of Llanberis especially, ancient moraines and polished rocks are distinctly visible.

I have now, I believe, laid before you all the great facts relative to glaciers which have a picturesque character, or which can be popularly described, and I cannot conclude this portion of my lecture better than by quoting Professor Forbes' eloquent comparison of the course of a glacier to the course of human life.

"Poets and philosophers have delighted to compare the course of human life to that of a river; perhaps a still apter simile might be found in the history of a glacier. Heaven-descended in its origin, it yet takes its mould and conformation from the hidden womb of the mountains which brought it forth. At first, soft and ductile, it acquires a character and firmness of its own, as an inevitable destiny urges it on its onward career. Jostled and constrained by the crosses and inequalities of its prescribed path, hedged in by impassable barriers,

which fix limits to its movements, it yields, groaning to its fate, and still travels forward, seamed with the scars of many a conflict with opposing obstacles. All this while, although wasting, it is renewed by an unseen power; it evaporates, but is not consumed. On its surface it bears the spoils which, during the progress of existence, it has made its own; often weighty burdens devoid of beauty or value, at times precious masses sparkling with gems or ore. Having at length attained its greatest width and extension, commanding admiration by its beauty and power, waste predominates over supply; the vital springs begin to fail; it stoops into an attitude of decrepitude; it drops the burdens one by one, which it had borne so proudly aloft; its dissolution is inevitable. But as it is resolved into its elements, it takes all at once a new, and livelier, and disembarrassed form; from the wreck of its members it arises, 'another, yet the same,'—a noble, full-bodied, arrowy stream, which leaps, rejoicing over the obstacles which before had staid its progress, and hastens through fertile valleys towards a freer existence, and a final union in the ocean with the boundless and the infinite!"

PART II.

VEGETABLE AND ANIMAL LIFE.—HABITS OF THE SWISS. —PASSES. — ASCENTS OF MOUNTAINS.

HAVING given you an account of all the principal points of interest connected with glaciers, I will now proceed to another subject; and I think the clothing of that part of the surface which is not chained in everlasting ice and snow, I mean the vegetation, may next claim our notice.

It is not my intention, nor indeed would it be in my power, to give you a botanical account of Switzerland, but it would be an unpardonable omission were I to pass over one of the great charms of that lovely country. I can assure you that the profusion and variety of flowers is quite surprising, even to an Englishman; and it is very striking to see beautiful flowers growing at the very edge of the ice and snow. No sooner does the snow melt, or the ice retreat, conquered by its enemy the summer sun, than instantly the ground is covered with lovely flowers. Crocuses and anemones spring up in the greatest profusion.

The chief favourites of all Swiss travellers are the gentians, of which several species are met with. Most of the species are of the deepest blue or purple that can be conceived, and growing, as they often do, close to the snow, their beautiful colour is rendered more striking by the contrast.

The Alpine rose, as it is improperly called, or rhododendron, is perhaps the greatest floral ornament of the Swiss mountains. In many places the mountain side is made one blaze of pink flowers by the profusion in which the rhododendron grows. I have sometimes, when climbing the mountains, had to force my way through these flowers, and I can assure you they were growing so thickly that my progress was thereby rendered most laborious. As the summer advances it is very interesting to observe the different progress of the various flowers at different heights. In the morning, when starting from the valley, you observe with regret that the lovely Alpine rose has ceased to flower. In the course of two or three hours you have ascended a few thousand feet; and there you find your favourite in full beauty, and higher still you find it is only in bud. After a week or two you have to reach the highest point at which the rhododendron flowers, to find a single blossom. So it is with all the flowers. In the morning you start on your journey oppressed with the

heat of summer in all its might, a few hours bring you into spring, and a few hours more into the depth of everlasting winter. The winter, however, which you then reach, is not dark and gloomy, but bright, fresh, and exhilarating; the breast heaves with increased strength, the eye brightens, and the whole man exults in the elastic freshness of the air, and the glories of the surrounding scene. The plants, too, participate in the strength-giving effect of the mountain air. As you ascend, the flowers are of a deeper hue, and of a larger size than those found at a less elevation. The intensity of the light, and the purity and diminished pressure of the atmosphere, are supposed to produce this result.

A glance at the vegetation of Switzerland would be incomplete without a description of the Alpine pastures, called Alps, and from which, indeed, the Swiss mountains take their name. Wherever there is a patch of soil high up among the barren rocks, there the vegetation is most luxuriant. It is very striking, as you are travelling along a valley, or on the bosom of a peaceful lake, surrounded on all sides by almost inaccessible precipices and barren rocks, to see high, far above you, little specks which on examination you find to be numerous chalets, with here or there a church.

These are the summer abodes of the Swiss farmers, placed amid these Alpine pastures. In the spring they take their cows and sheep to feed on the rich luxuriant herbage which grows in those elevated oases in such profusion. Sometimes, to reach these spots, the cattle have to be driven over the ice and snow; sometimes the sheep are carried on men's shoulders, and sometimes hauled by ropes up the precipices, at the summit of which the luxuriant vegetation is to be found. I shall tell you more about the Alpine life of the shepherds when I touch upon the manners and customs of the people.

The principal trees of Switzerland are species of the cone-bearing trees or fir tribe. These are called by the Germans needle-woods or spike-woods, from the shape of their leaves, while the broad-leaved trees are called leaf-woods. The needle-woods are on the mountains, and the leaf-woods in the valleys. In the valleys walnut trees are very plentiful, and in many places form beautiful avenues. Lime trees are also found in considerable abundance. The elm is rarely seen, and the oak is nearly eradicated. There are a good many beeches and sycamores, but the needle-woods are the most general and most appropriate clothing of the mountains; the pyramidal growth, pointing and reaching up into the sky, seems to harmonise so perfectly with the lofty

mountains. When the Alps are crossed into Italy, the needle-woods soon disappear, and are replaced by the chestnut. There is, however, such general harmony in nature, that where any particular tree is the natural growth of the soil, there it looks well; and the chestnut on the mountains looks very rich and beautiful. But I confess I think the fir the more harmonious clothing of the cloud-aspiring mountains. There are many species of the fir tribe found in Switzerland, from the species that creeps along the ground and clings to the rocks, to the lofty Wettertanne, which grows to the height of 130 feet.

From the vegetable world we naturally go on to the animal world. There used to be a great many bears and wolves in Switzerland, but now they are hardly ever heard of. There are, of course, plenty of small animals—such as foxes, badgers, hares, and rabbits; but the most interesting animals are the chamois, the ibex, and the marmot.

There used to be immense numbers of chamois, but they have been so continually hunted and shot down that they are now comparatively rare, and are become very wary. I saw some chamois when we were crossing the Theodule glacier. There were some bare rocks on the side, and two old chamois, with a young one, descended from these rocks and

crossed the glacier before us. They stopped occasionally to look at us, and at last disappeared down the other side of the glacier. The chamois is a kind of antelope, and is the only antelope found in Europe; a full-sized chamois weighs about sixty pounds. At night they shelter themselves among the rocks, and at daybreak they graze down the sides of the mountains. They always keep a very keen look-out for danger, and it is believed they post sentinels to look out and give the alarm. They are also wonderfully active. They can spring across a great precipice sixteen or eighteen feet wide, and alight on a ledge of rock no bigger than your hand, and they can bound over a paling fourteen feet high and alight quite softly on the other side, apparently without the least exertion. They are, consequently, very difficult to approach, and in fact chamois hunting requires more skill, patience, strength, and nerve than almost any sport in the world.

The chamois hunter is sometimes out for several days together, carrying his scanty food with him, and sleeping in holes in the rocks. Sometimes it is so cold that he does not dare to go to sleep, and he then fills up the weary hours by moving heavy stones from one place to another to keep himself warm and to prevent his falling asleep. It takes him a long time

to find his game, and then he often has to go miles round before he can approach it unperceived. At last he gets a shot — he has killed a chamois, but it has fallen down a precipice; he has miles to go round before he can get to it, and then he has to carry it miles on his back before he can reach his home. Poor fellow, after all he gets but little for it; but there is such fascination in the sport that no man gives it up, and very few chamois hunters die in their beds. Sometimes in pursuit of his game a chamois hunter will jump down on a ledge of rock, and when he gets there he finds it hardly possible to get either backward or forward. A chamois hunter once jumped on to a ledge of this kind with an awful precipice below him. The ledge was a loose crumbling slaty rock which kept breaking away. He saw that the only way to escape was to lie down flat on his face, and to creep along to the corner, where he thought he could get round on to firm ground. Well, he went creeping on, when all of a sudden he saw a shadow on the rock. He turned his head round and saw a great eagle ready to attack him. He managed to twist himself round and present his gun at the bird, but he was afraid to fire it for fear the shock should shake him off his narrow resting-place. At last the eagle flew away,

and after immense exertions the chamois hunter escaped. Another chamois hunter was going across a glacier, when he slipped and fell into a crevasse. Wonderful to relate he broke no bones, and when he got to the bottom he found it was dry. He groped about in the dark, and found a hollow passage that had been worn by the water. He crept along this till he got into daylight, and at last he escaped.

The ibex is a kind of goat. It is much larger than the chamois, and its horns also are much larger in proportion. It is very much scarcer than the chamois, and indeed it is doubtful if any still remain. The ibex is even more difficult to shoot than the chamois, for at daybreak it gets up into the highest mountains, and unless the hunter gets above it before daylight he has very little chance of getting a shot. A sportsman with three companions had been looking out for ibexes for some days, when at last they discovered some lying on a rock. To get within shot they had to go along a narrow ledge, about a foot wide, on the face of a precipice. A great deal of snow had just fallen, and consequently this ledge was slippery and dangerous. On they went, but suddenly one of them got giddy, fell over, and was dashed to pieces. His companions crept

back, awe-struck; they searched for the dead body, but all in vain, it was never found.

The marmot is a harmless little animal, about twice the size of a rabbit. You have probably often seen Italian or Swiss boys about with them in boxes. They are very interesting. They live in deep burrows, and sleep nearly all through the winter. They have winter burrows and summer burrows. In winter they make their holes much lower down the mountains for the sake of the warmth. They make first of all a long passage, at the end of which is a large chamber, big enough to hold fifteen or sixteen, for the father and mother and the whole family of young ones live together during the winter. This chamber is well filled with hay which serves them for warmth, and for food if they happen to wake up on a fine warm day. They cut the grass with their teeth, and thus make their hay and carry it into their holes about August. They are difficult to shoot or catch, as they keep a very sharp look out, sitting up on their hind legs, and when they are disturbed they make a kind of whistling bark, almost like a bird's note. In winter they are sometimes dug out of their holes, but in summer it is useless to attempt this, as they can burrow faster than they can be followed. In the winter they are surprised in their sleep. But

even digging marmots has its dangers. A father and son were digging for these animals, and the father had got into the burrow, when suddenly the earth gave way and buried him. The son then got in to make the hole larger, when the earth fell again and buried him too. The son was soon suffocated, but the father remained alive till the following day, when he was discovered and dug out. He died however almost immediately.

There is only one bird which it is worth while to describe to you, and this is the lämmergeier, or vulture of the Alps. It is not strictly speaking a vulture, as its neck is covered with feathers, but it is rather a connecting link between the vultures and the eagles. It is rare in Switzerland now. I did not see any. A full-grown bird measures nine or ten feet across the wings when open, and it is about four and a half feet long. It is very destructive to sheep and lambs; small animals it carries off in its claws, but sheep are too heavy for it. It sometimes attacks it prey, when too large to carry off, in a very singular manner; if it sees a sheep, a goat, or an old chamois, feeding near the brink of a precipice, it makes a swoop at it, making a dreadful noise with its wings. It thus frightens its prey to the edge of the precipice, dashes at it and knocks it over. It

has been known sometimes to attack children, and to carry them off to its young. These birds are very tenacious of life, as will be seen by the following story:—A peasant had caught a lämmergeier in a trap, and gave it several blows on the head, till he thought it was dead. He then slung it across his back and away he went. Before he had got far the bird recovered, and he had a desperate struggle with it before he could kill it.

I must now endeavour to give you some idea of the general appearance of the country, and to tell you about the people. Now, one of the circumstances that struck me most was the absence not only of gentlemen's seats, as we call them here, but of any houses and gardens, except those of the peasants, anywhere away from the towns. To us, who live in England, it seems extraordinary that rich people should not have country-houses far away from the towns, amid the beautiful mountains, to go to in summer. Near the towns and on the borders of the lakes there are often beautiful villas, but during the whole of my tour in Switzerland I believe I did not see a single "country-house," such as we find everywhere in England.

I believe that this arises from there being no large landed proprietors. The whole country is

divided into small patches. It is usually cultivated very well, but the people have to work very hard, much harder than the labourers do here. Men, women, and children are all at work from daybreak to sunset. The weights I have seen many of the women carry are quite surprising. The country generally is too hilly and rocky for carts and horses to be much used, and consequently the men, women, and children have to carry what in this country we should put into a cart. The hay is carried home in this way. Sometimes the hay is gathered together and an immense load is tied up and carried on the head, making the man look like a great toadstool, the hay being nearly all that is seen, and his legs looking like the stalk. In many places, however, they have a much better way of managing. They have a basket which looks more like a strawberry pottle than anything else, except that it is wider in proportion at the mouth, and it is, of course, altogether very much larger. It is about four feet long and two or three feet wide at the mouth. This is carried on the back, is fastened over the shoulders with straps, and rests on a kind of framework, with a ledge to prevent its slipping down. It is astonishing what enormous quantities of hay even women carry in this way. They literally look like walking hay-

stacks. In the country in Switzerland, all the people carry their loads in this way. Whether it is hay, or wood, or stones, or clothes, all goes into a basket of this kind. I am sure it is much easier to carry things in this way, than in your hands or merely slung over your back. You have your hands at liberty, which is a great point. I have seen men walking away up mountains as upright as possible, carrying weights that would surprise you. I have had some experience myself of this way of carrying weights. My clothes were all packed up in a knapsack like a soldier's. I did not often carry it myself, but I did sometimes, and got on very well; but if I had had to carry it in my hand I should soon have had to stop. Well, that is the way the Swiss carry their harvest home.

The hay in Switzerland is said to be very good, but it is very different from the hay in this country. It is full of herbs and flowers of all sorts, and they say that on that account the cattle like it exceedingly. Some of the crops you see in Switzerland are quite different from the crops you see here. In some parts there is a good deal of maize or Indian corn, which looks very beautiful and is very useful. It has been tried in this country, but it does not succeed well. A great deal of hemp is also grown, and

this is a very beautiful looking crop. It grows luxuriantly, and is beautifully fresh and green. Then, in telling you about the crops, I must not forget to tell you that in many parts of Switzerland the vine grows well, and is a very important crop.

There are not many sheep in Switzerland; at least you very seldom see them, and I believe there are not many. There are beautiful pastures for them up in the mountains, but they would be difficult to keep in winter, as there are hardly any turnips grown in Switzerland. We met some flocks in the mountains, which were so tame and so accustomed to look on man as their friend and protector, that they kept following us, and one, smelling a crust of bread in my pocket, put his nose in and began to eat it. We were, at last, obliged to drive them away. There is another reason why the sheep follow you in this way. They are very fond of salt, and the shepherds carry salt up the mountains for them. Accordingly whenever they see a man they think he has got some salt for them.

Great quantities of goats also are kept, but the great staple of Swiss farming is the cattle. I must tell you about the places where they feed. I have already given you some account of the pastures, but I shall now enter into more details relative to them.

As you travel along in Switzerland, you often see great numbers of huts, or cottages, or châlets, as they are called, dotted about very high up the mountains, in places which seem almost inaccessible. You wonder why they should be built up there, —what people should live up there for. On inquiry, you find, and as you get nearer you sometimes see, that they are built close to a beautiful green pasture. These pastures are among the curiosities of the Alps. Almost wherever there is a flat piece of ground, there is a beautiful meadow. These pastures are called Alps, and it is from them that the mountains take their name. Now these meadows are the favourite feeding grounds of the cattle, which are taken up there for the summer months. The châlets are the houses in which the cow-herds live in the summer, when they are with the cattle. In the spring they move up with their wives, families, and the cattle. In the winter, many of these châlets are entirely covered up and hidden in the snow.

Some of these châlets are very nice and comfortable, but some of them are very rough; and in some of them, which are very high up the mountains, there are only men living. I slept in one of these châlets, and it was certainly very rough indeed. It was a place where butter and cheese were made, and

there were several hundred cows kept there, all of which came home to their stalls every evening, and there were seven or eight men to look after them. There was no other human being living within many miles. Well, we got to this place about nine o'clock in the evening, after a very rough and difficult clamber down the steep side of a mountain, where our guide lost his way. We had intended to sleep at this châlet, but as we got near the place where we expected to see it, we saw what we took for a village, and accordingly went on. We were very much puzzled, for we knew there was no village near. However, after going on for about a mile, we saw no house, and found we had made a mistake, so we went back to what we took for a village. We then found that the buildings we had taken for houses were the cow-stalls, but they were built so strongly that they looked like houses. They were obliged to be built strongly, for during more than half the year they are buried in snow, so that they are quite hidden. Well, we went to the building where the men lived, and although we had expected something rather rough, I must say it looked, and I may add smelt, rather more rough and unpleasant than we expected. The smell of the cheese was rather too strong to be nice. The floor was clay or mud and

rather damp; there was one table, a few benches and stools, but there was a capital wood fire in the corner on the floor, and hanging over it an immense iron cauldron, in which the milk was boiled and rocked. We asked the men if they would let us sleep there. There were three of us and two guides, five in all. There were three or four men who lived in this châlet, and the rest of the men who looked after the cows and the cheese—there were no women—slept somewhere with the cows. They said they had two beds, and would give them up to us. Our guides said they would sleep on the tables, and so there were two beds for us three. One was a large bed and the other a small one. At last it was settled that I should sleep by myself in the small bed, and that my two friends should sleep in the other. Now, when I talk about beds, you must not imagine we had commodious four-posters, with clean sheets, and a comfortable pillow. The beds were made in this way. There was a rough framework of fir-poles, making a sort of box. This was filled with coarse hay: on the hay was laid something rough intended for a sheet, with another over it; then some rough sort of a blanket was thrown on the top, and there was your bed all ready made. Now good clean hay, or even nice clean *long* straw, would make a com-

fortable bed enough; but it was bad short rough hay, and before you had been long in bed, and had rolled over once or twice, you got all mixed up in the hay; it got into your hair, it got into your eyes, it got into your nose, it got everywhere. There were, moreover, plenty of companions, for I had a mouse, and fleas innumerable, in my bed.

Before I leave the châlet, I must tell you about the stools the men sat on. They had only one leg, and they kept them buckled on with the leg sticking out behind like a tail. This looked certainly rather funny; but then, you see, the men had the stools ready whenever they wanted to sit down. Their principal use, however, was for milking-stools.

But we must now go back to the cattle. It is a very joyful day in the spring when the snow is all gone from the pastures and the cattle go forth from their stalls. They seem to know where they are going, and are full of life and spirits, frisking about and enjoying themselves. A grand procession is formed. Every cow has a bell round her neck; but one is chosen as the leader, and, of course, the finest and handsomest cow is the one chosen. She has a larger, finer-toned bell, which is worth a good deal of money. When the leader is once settled in her place, it is said she will never allow another cow to go before

her. A horse laden with the furniture necessary for the châlet, brings up the rear. The cattle are usually very tractable and quiet, but every now and then something occurs which rouses and disturbs them. A thunder-storm often greatly alarms them, and on such occasions they are very apt to run wildly about, and fall down the precipices. When the cow-herd, therefore, sees a storm coming on, he collects his cattle together, and drives them into a circle with their heads inwards. Then he goes round and speaks to them; they feel he is their protector, and keep quiet. If a cow is slaughtered, and any part of the carcase is left above the ground, or even is buried, it excites the cattle in a most mysterious way. They are sure to smell it out; they gather round the spot, paw the ground, and at last they have a dreadful battle.

These cattle usually belong to a great number of people; one has two cows, another four or five, another perhaps a dozen, and so on. The owners of the cows, most of whom are poor peasants, send a few men, and generally their families go with them, to take care of and attend to them. There is one man to about twenty-five or thirty cows, whose duty it is to look after them, milk them, make the cheese and butter, and keep an account of all they

produce. Now you would probably like to know how the accounts are kept. In some places there is a complete list of the cows, each having a name or number, and an exact account is taken every day of the quantity of milk yielded by each cow. This is sent at certain stated times to the owners of the cows, who, from this information, can calculate how much butter and cheese should come to their share. In other places, before the cows go up to the mountains, each is milked for three or four days, and an exact account is taken of the quantity yielded; on the return of the cows this is done again, and in this way the owners are able to estimate about how much milk each cow has given while she was in the mountains. The cheese and butter are divided among the owners according to the number and value of their cows. The two plans I have mentioned are the practice where the mountain belongs to the commune, or parish as we should call it. In other places the whole mountain either belongs to or is hired by one or by a few persons; and in such cases the possessor of the mountain hires the cows. He gives the owners so much for the use of the cows during the season he has the milk. The owners do not get very much, only about 10*s.* or 12*s.* for each cow for one season. The return of the cows in the

autumn is as great a festival as their departure; but the cows return to their stalls in a rather more steady, sedate manner.

I must now return to the general appearance of the country, for I must tell you something about the Rivers, Lakes, Cities, and the Passes, and give you an account of the ascents of some of the high mountains. All the great towns of Switzerland are situated on the lakes and rivers; and as the lakes are only widened rivers, I cannot do better than trace the rivers from their sources, in order to give you a general idea of the country. As I have already told you, the rivers rise in the glaciers or in the mountains. There are two principal groups of mountains in Switzerland — the Jura range, bounding Switzerland on the west, and the Alps. It is rather singular that the Jura range does not give rise to a single large river, and this probably is caused in part from there being no glaciers on the Jura. The Jura range is not lofty. The Alps may be considered as one chain, although in some places they are cut through by the rivers, and thus separated into distinct groups. These are full of glaciers, and give rise to several large rivers.

There are four great rivers rising in Switzerland, the Rhine, the Rhone, the Reuss, and the Aar.

There are many smaller rivers and streams, and, in fact, every glacier forms a stream or rivulet which joins with some other, and thus keeps on increasing till it falls into a large river; but the four I have mentioned are the principal rivers in Switzerland.

The Rhone rises in the glaciers of that name, cuts through the Alps, and forms the valley of the Rhone, with the Bernese Alps on one side, and the Mont Blanc and Monte Rosa group of Alps on the other. It passes through Sion, Martigny, and other small towns, and then swells out into the Lake of Geneva. On this lake are situated two of the principal towns of Switzerland, Lausanne and Geneva, — the latter celebrated for its manufacture of watches; and on the west of the lake are the Jura mountains. The view from these is most magnificent. You see a range of mountains extending for nearly 300 miles, or as far as from London to Newcastle; and on a perfectly clear day you may see them reflected in the lake. The lake is as large as many English counties. Mont Blanc is distant from the lake about sixty miles, or farther than from London to Brighton; on a clear day you can see it perfectly reflected in the lake. When the Rhone enters the lake it is thick and muddy; there is no transparency in its water — but it leaves all its mud in the lake and comes out at

the other end as clear as crystal, and of the most beautiful blue colour you can possibly conceive. It is there so clear that when you stand on the bridge at Geneva, where the river is fourteen or sixteen feet deep, you can see every stone at the bottom, and the fish lying among them or swimming about. On leaving Geneva the Rhone joins a small river called the Arve, rising from the glaciers of Mont Blanc, which is a dirty, muddy stream, like most glacier streams. The Rhone preserves its purity for some time, like a beautiful spirit maintaining its purity amid the grossness and coarseness of the world; but, alas! after a time it yields, the mud and coarseness of the Arve overpower it, and all its lovely purity is gone.

There are two branches of the Rhine, the principal of which rises in the Rheinwald glacier, flows through Lake Constance, on which is situated the town of that name, then goes on to Schaffhausen, celebrated for its falls, and finally leaves Switzerland at Basle. The Reuss rises in a small lake at the summit of the St. Gothard Pass, runs by Altorf into the Lake of Lucerne, and finally falls into the Aar. The Aar rises in the glacier of that name, runs through the Lakes of Brienz and Thun; it then nearly surrounds the city of Berne,

one of the most important in Switzerland, and, after joining the Reuss, it finally falls into the mighty Rhine.

The Lake of Lucerne is one of the most beautiful in Switzerland: the town of Lucerne is situated on its banks, and the two well-known mountains — the Rigi and Mount Pilate rise from the lake. Travellers sleep on the top of the Rigi to see the sun rise; but, having given an account of the magnificent scene in my "Journal," I need not repeat it here. The other lakes in Switzerland are Lake Wallenstadt, a very wild and picturesque lake, which is fed by various small streams; it empties itself into the Limmat River, or Linth Canal, as it is called, which flows into the Lake of Zurich, and thence into the Aar, and thus the Limmat also contributes to the mighty Rhine. In the west of Switzerland is the Lake of Neufchatel, on which is situated the town of the same name, celebrated for its cheese, but recently more celebrated as the scene of an insurrection which might have again plunged Europe into war. These lakes add greatly to the beauty of Switzerland. In some Eastern language they are called the "Eyes of the Land;" and well do they deserve that name, for the eye does not light up the human face more than water does the land.

I must now describe to you what are called the Passes of the Alps, but I must first explain what a pass is. Suppose there is a vast chain of mountains which you must get over or through to arrive at the other side. You know that to go straight over them would in many cases be quite impossible, and in all cases extremely laborious. You therefore look out for some place where the mountains are not so high as elsewhere—where two mountains join, or where a valley runs up into the mountains. Well, we will suppose that you are in a strange country and have no one to guide you; you look out for a stream, for you know the streams always run through the valleys, and, indeed, make them. Well, you follow up the stream; it takes you into a valley which runs up between two mountains, and at last you reach a kind of shoulder from which you can see down into the valley on the other side; this is called a Pass. When you are in Switzerland you cannot get further south without going over one of these passes, and there are many passes leading from one part of Switzerland to another. There are more than fifty of these passes in Switzerland. Some have been made fit for carriages with immense labour.

The principal passes fit for carriages are the Simplon, the St. Gothard, the Splugen, and the

Bernadine. To enable carriages to ascend and descend, the road is made to wind very much; and when you look down, you often see a dozen or more turns in the road, which lies beneath you like a great snake. There is usually a low wall on the side of the precipice, but sometimes only a slight railing, which would break if a carriage went against it, and then the carriage would be dashed to pieces over the precipice. Heavy carriages, however, go down these roads in safety and at a good speed. There is always a very powerful drag attached to the carriage, which the driver can fix on and take off without moving from his box, or stopping. If this drag were made of iron or steel, it would be cut through in a single journey; but it is usually made of a great log of wood,—a pine tree cut in half. There are very seldom accidents, but they do occur sometimes. I was travelling down the St. Gothard Pass, when the carriage suddenly upset while turning a corner. I was thrown against a rock and cut a good deal, but it was fortunate we were thrown inwards; had we been thrown the other way we should have been dashed to pieces over the precipice. The steepness is not the only danger of these passes. Avalanches and mountain torrents sometimes sweep away the road, and hurl carriages, horses, and tra-

vellers down the precipice. The places where these avalanches are likely to fall are, however, well known; and in such places the roads are now protected by long galleries or tunnels, some nearly half a mile long, built of the strongest masonry. The avalanches slide over these, and sometimes also the torrents rush beneath them. On some of the passes there are nearly a dozen of these tunnels on each side.

There are other passes not fit for carriages, but fit for mules. It is not more than forty or fifty years ago that there was not a single pass fit for carriages, and then all the travelling was on the backs of mules or horses. The principal of these passes are the Gemmi, the Tête Noire, the Furca, and the Grimsel.

There are others, again, which can only be traversed on foot, such as the Joch Pass; and others, again, which are nothing but ice and snow, such as the Theodule and the Tschingel. These passes are extremely interesting and curious. You pass from winter to summer in a few hours. You begin to ascend among the grapes, and the maize, and the corn; you then get into the pine forests; from these you emerge on a beautiful pasture,—an alp, covered with cattle. You again ascend, and get into short

and scanty grass and herbage; after a time, not a shrub is to be seen, and you get to the snow and ice; you then descend, and in a few hours you are again in the burning sultry plain.

A friend of mine had a remarkable excursion over the Theodule Pass. He arrived at Zermatt at the beginning of October with the intention of crossing the Theodule. On summoning the landlord, however, to a conference, he found his opinion to be that it was too late in the season. Nevertheless, he sent for one of the guides, who confirmed the landlord's statement. He said, "A great deal of snow has recently fallen, it is snowing now, and it is impossible to cross the pass." Accordingly, my friend gave up all idea of crossing; but, to his great surprise, in the course of the evening the guide returned to say that they could go. My friend was naturally surprised, and asked what had made the guide change his views. He said that a drove of about 150 cattle was going across early the following morning to a market in the Val Tournanche, and that they could follow in the track of the cattle. Accordingly, they started next morning about three or four o'clock, having given the cattle an hour's start. It was some hours before they overtook the cattle, and then they rested to take break-

fast. The long line of cattle, interspersed with the peasants winding along the snow, made an extremely picturesque scene. My friend and his guide started again, after giving the cattle sufficient time, as they thought, to get moderately ahead; but they did not see them again till they had arrived at the end of their journey. Soon after they resumed their march a violent *tourmente*, or storm of wind and snow, arose, and raged with such violence that they were obliged to stand still, with their backs to the storm, till its fury had abated. All traces of the cattle were now entirely covered by the snow, and obliterated. But fortunately the cattle drivers, intending to return to Zermatt, had taken with them bundles of long sticks which they fixed in the snow at intervals, and these served as guide-posts to the travellers. On they went for some hours, when at last they heard groans beneath the snow. They felt, however, it was impossible to stop. Their own lives would have been sacrificed without benefit to the sufferers, whether man or beast, that were buried in the snow. When at last they arrived at their journey's end, they found that about a dozen cattle had been buried in a crevasse, and covered up by the snow; and it was the groaning of these unfortunate beasts that had been heard by the travellers.

At the summit of the passes used for the transport of merchandise there is usually a hospice or house of refuge or repose for travellers; and it may easily be imagined how welcome they are to the weary traveller. It is singular to see bales of goods carried over these wild passes; but it would be in vain for me to attempt to equal the eloquent description of such a scene by Tschudi, and I shall therefore quote the following passage from his "Animal Life in the Alps:"— *

"Strange and wild is the aspect of the mountain world brought so immediately before the traveller's eye, as he visits these passes and hospices. Around, in savage majesty, stand icy peaks and galleries of rock never trodden by human foot, scarcely even by that of the chamois; as yet unexplored by the researches of science; perhaps not even gifted with a name. Yet at their very feet the noisy caravans of commerce are passing and repassing, and the twanging posthorn re-echoes among their heights, mingling with the bells of the mules, and the many-tongued voices of human beings. Their ancient repose is undisturbed by the busy hum: they slumber on for their thousands of years, dreaming, it may be, of the

* Taken from Miss Merivale's excellent translation.

ocean waves which once washed against them; of the colossal fire which upheaved them from their mother earth; of the variegated shells and fish which sported on their peaks and in their clefts; then how the water slowly ebbed away; how the luxuriant shrubs and palms of the south waved freshly over their summits; how next their slopes were clothed with the chestnut and the lime; and how, finally, all life sank down gradually into the valleys, the storms swept off their coating of soil, their winters lengthened and their summers shortened; how the snow, once an element unknown to them, first became stationary on their surface, and then towered up in lofty masses, till snow and ice, and gloom and storm, became fixed features of the realm. Perhaps in their inmost recesses may be traced the ruins of a yet more beauteous primeval state, veins of precious gold running deep within the bosom of the rocks, and beds of crystal and nests of glittering gems. But to the outward eye they are dreary, lifeless masses; and each succeeding century buries them more deeply beneath their load of snow and ice, and crumbles away their naked ribs."

I must now wind up with a few ascents of lofty mountains. The first I shall describe to you is that of the Wetterhorn, which was ascended, for the first

time, three years ago, by Mr. Wills.* He was accompanied by four guides and a porter. A porter was quite necessary, as they had to carry provisions for the whole party for two days, blankets to cover them at night, and ropes to tie them together. They also encumbered themselves with one very needless weight: when they were about to start one of the party was missing, and on Mr. Wills inquiring where he was, he was told he had gone to the blacksmith's for a flag. As this mountain had never been ascended, they determined to plant a flag at the top; but the blackmith's seemed a very curious place to go to for it. It turned out, however, that it was to be an iron flag, three feet long and two feet wide, with an iron pole ten or twelve feet long to support it. This was rather an awkward thing to carry up a precipice of ice and snow. The place from which they started was Grindelwald, and they left the inn about midday. It would have been of no use to have started earlier, for there was a hole in the rocks where they were to sleep, and it would not have helped them to have arrived there early. Well, the first day's journey was not alarmingly difficult, and they arrived at the hole where they were to sleep. This was formed by three rocks

* Taken from his "Wandering among the High Alps."

which had fallen over each other, and the space between the outside had got filled with mould, so that the wind was kept out and they were sure to be warm enough. It held the six men, but it was rather a tight fit. They found some hay in the cavern, which had been left by chamois hunters, and they all turned in to sleep. Mr. Wills, however, did not find it very comfortable, and, after trying for some hours to get to sleep, he found it so stifling and hot that he managed to crawl out with one of the guides: there was a stream flowing from the ice close by the cavern, and in this Mr. Wills bathed, and was greatly refreshed; the stars were shining brightly, looking like sparks of fire, the sky looked almost black, and the glaciers and ice mountains looked like ghosts in the pale moonlight. At last they started, groping their way with lanterns till daybreak. It would not interest you were I to describe every step of the way; and I shall, therefore, mention only the principal incidents. Their first difficulty was the passage of some sharp ridges of rock, something like the leaves of an artichoke, but hundreds of feet high; the rock was so loose that they had to try every slab of stone before they put their foot on it, and hundreds of stones went rolling down over the precipice; it was so steep and

so narrow at the top that they passed their arms over the ridge to hold on; they took the mountain under their arm, in fact. Well, at last they got to the end of these troubles, and then they found themselves at the foot of a steep wall of ice, at the top of which was a cornice of ice, overhanging like a great fringe or curtain, with icicles hanging down as big as a man. It was clear they must cut their way through this. Now this wall of ice was covered with snow about three inches deep; it was, therefore, not deep enough to support them, and so they had to cut every step with their hatchets through the snow into the ice; the bits of ice that fell rolled over the precipice; the guides went in front to cut the steps. At last all was ready up to the fringe of ice. Then Mr. Wills and the guides left with him went up, all tied together; at last they got to the fringe of ice, and then one of the guides hacked away at it to make an opening to get through; they thought that when they had got through this there would be a dome to get up before they arrived at the top; all of a sudden the guide who was hacking at the ice called out "I see blue sky." He had cut through the cornice and found they were at the top. The top was so narrow that they sat across it as if they were on horseback, and the other side was

much steeper than the one they had come up. They looked down a precipice of at least 10,000 feet into the green valley below them, and on this awful spot they actually planted their iron flag, and also two fir-trees, which had been brought up by some chamois hunters who had followed them.

Of the ascent of the Jungfrau I have not much to tell you, but there are a few points of interest. This mountain was ascended by Mr. Forbes: one remarkable fact is, that, as they walked, their footsteps were seemingly all marked in blood; wherever they trod they left a bloody footstep behind them. This arose from the presence of what is called red snow; the snow itself is not red, however, but in some places a red fungus grows in the snow, and this was the case here. Fresh snow had fallen and covered the red snow, but wherever they stepped they broke through this upper layer and laid bare the red fungus crushed beneath. Another interesting and frightful circumstance was this: in some places they walked on the edge of the precipice, where it turned out the ice was overhanging, and they were walking on the ice. One of the guides, as he was walking, actually thrust his alpenstock through the ice, so that if he had dropped his stick through the hole, it would have fallen down an immeasurable

abyss. Just as they arrived at the top there was a very narrow ridge, which turned out to be nothing but hardened snow, for one of the party actually pushed his alpenstock through, and it came out on the other side. As they were descending, a curious circumstance happened: they had to clamber down a steep wall of ice, every footstep in a hole that had been cut as they went up. It was so steep that they went with their faces to the mountain; Mr. Forbes happened to look down through his legs and he saw a black mass falling, which looked like one of the guides falling down the precipice; after a time, however, he discovered that it was an eagle which had swooped down to examine the basket of provisions they had left below.

I do not intend to give you a minute account of the ascent of Mont Blanc, but only to seize some prominent points. The time taken to ascend and descend, in actual walking, is about twenty-four hours; but travellers almost always sleep half-way up, and therefore the whole excursion takes thirty-five hours. So many people have ascended Mont Blanc lately (principally Englishmen and some English ladies), that its dangers and difficulties have been supposed to be less than they actually are. There is no doubt, however, that it is an expedition

requiring great nerve, strength, and perseverance; and a man must be in good condition to accomplish it. Many have failed, and many are dragged to the top more dead than alive. The ascent begins in the usual way, — first, by the side of a glacier, then through a forest, and so on up steep climbing till you get to the Glacier des Bossons. From this point it is nearly all ice and snow. After this glacier you soon reach the Grand Mulets, where travellers sleep. These are some isolated steep rocks, which afford sufficient shelter for a night's rest, and now there is a rough hut erected on them. From hence you soon reach the Glacier du Taconnay; you then have a steep ascent to the Grand Plateau, a great plain of snow two miles long, with a wall of ice called the Mur de la Côte at the end. In this steps have to be cut, and so you arrive at the top. Near the top you now turn to the left to the Rochers Rouges, but formerly travellers used to go straight up. This, however, was found to be dangerous, and another route is now taken. Dr. Hamel and his party were overwhelmed in an avalanche, and three of the guides were killed. A new route has lately been discovered affording easier access to the summit, but it has not yet been tried sufficiently often to be sure that it is always practicable.

A friend of mine who has ascended Mont Blanc told me a few incidents connected with his ascent. He said, that one of the circumstances that struck him most, was the appearance of the sky at night from the Grand Mulets: the sky looked very dark, and the stars hung like lamps in the sky. In this country, if you look at the sky it seems as if the stars were nearly all the same distance off; but at the height of the Grand Mulets the atmosphere is so dry and clear that you see the stars more distinctly, and they seem to be suspended — to hang — in the sky at different distances. You see a star which seems comparatively near, and you look at another which is evidently further off, and so on, star after star, till you seem to look into infinity, and to realise the boundlessness of space. The impression on the mind is overwhelming, — all the while, from time to time, you hear the roar of an avalanche. When my friend arrived near the summit, although he is a first-rate mountaineer, he felt the effect of the rarefied mountain air, which gave him a feeling of sea-sickness, and took away his appetite. He found he could not use a telescope at the summit, it made him giddy. These feelings went off directly he had descended a few thousand feet. A dog went up with him; one of the guides asked leave to bring his

dog with him, as he said that a dog that had been to the top of Mont Blanc would be worth a good deal of money. My friend thought the dog would be a great nuisance, and refused. Away they went without the dog. Of course the dog soon overtook them, the guide protesting he had ordered him to be tied up. Well, the dog *was* a nuisance; he got between their legs and bothered them, and then they had to throw him over the crevasses; he was what is called a Spitz dog, — these dogs have very pointed noses, sharp black eyes, and their tails always curl over their backs. Going up the mountain had an extraordinary effect on this dog. It made him uncurl his tail. As he went up, his tail gradually got straighter and straighter, till at last it was as straight as a broomstick. No Spitz dog's tail was ever before known to uncurl. As he came down, his tail gradually curled up again as usual. As the dog got towards the top of the mountain the air had the same effect on him as it had on human beings. My friend had taken up a cold chicken with him — it was cold enough you may imagine; and when he got to the top he thought he would eat, but he found he could not swallow a morsel. So he cut off a bit for the poor dog. The dog rushed at it as if he would have eaten it up ten times over; but he

could not manage it; he bit it and bit it, but his throat was so dry and his mouth was so parched, it would not go down, and at last the poor brute dropped it without eating a morsel.

I will now conclude, and if I have awakened in you a love for the beauties of nature, my time will have been well spent. I have described to you a country which is considered to combine beauty and sublimity to a greater extent than any country in the world. In other countries the mountains may be higher; but nowhere is there the same combination of lofty snow-clad mountains, with rivers, lakes, forests, and cultivation. If I have roused in you a love of nature, you will find even in this country ample scope for its enjoyment. We have here the beautiful woods, the solemn star-lit night, the sunrise and sunset, the dewy eve and incense-breathing morn. We have beautiful flowers and innumerable living things worthy of our study; and, believe me, the intelligent study and love of the works of nature affords the purest and most lasting source of happiness this world provides.

APPENDIX.

NOTES

ON

BEDDING, CLEAVAGE, AND JOINTS IN ROCK MASSES;

COMPARED WITH

NEVÉ STRATIFICATION, VEINED STRUCTURE,

AND

CREVASSES OF GLACIERS.

By the Rev. S. HAUGHTON, M.A.
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Geologists are familiar with three sets of planes in rock masses, viz.:—

1. Bedding.
2. Cleavage.
3. Joints.

The first of these, bedding, is of mechanical origin, and arises from the successive deposition of mud and sand held mechanically in suspension in water.

The second, cleavage, is developed principally in mud-

stones or slates, but often occurs also in limestones and sandstones. The planes of cleavage are close together, and divide the rock into thin laminæ, more parallel to each other than the laminæ of stratification.

The third, joints, are planes occurring at considerable distances from each other, 20 to 50 yards; the fracture of the rock is clean, sometimes cutting a fossil shell into two portions, and generally with a void interval of half to four inches.

These three sets of planes appear to me to be comparable with the following recognised structures in glaciers:

1. Nevé Stratification.
2. Veined Structure.
3. Crevasses.

Mr. Forbes has confounded the Nevé stratification with the veined structure, but appears to have formed a correct idea of the origin of crevasses, which, as he observes, are found to point *up* the valleys and intersect the "dirt bands" at angles approaching to 90°.

The true solution of the problem presented by glaciers involves also the solution of the problem of rock masses.

Two theories have been proposed to account for this structure in rocks:—

1st. The crystalline theory.
2nd. The mechanical theory.

The crystalline theory is best illustrated by an example.

Let us take an hexagonal prism of quartz, terminated by an hexagonal pyramid. The six planes of this pyramid are divisible into two groups: three alternate planes

are cleavage planes corresponding with the face of the primitive rhombohedron, and three are joint planes, generally called secondary planes.

The crystal may be cleaved indefinitely parallel to the first system of planes ; but cannot be cleaved parallel to the second system of planes.

The advocates of the crystallisation theory assert that the first system of planes is analogous to cleavage, and the second system to jointed structure.

In the glacier, these systems of planes would correspond with veined structure and crevasses.

According to the mechanical theory of cleavage and joints, the cleavage planes are perpendicular to the lines of *maximum* pressure, and the joints are perpendicular to the lines of *minimum* pressure ; this minimum pressure frequently becoming negative, or, in other words, becoming a rupturing force, and not a pressure at all.

In the case of the glacier, when the ice passes in its onward flow, through a narrow gorge of the valley, the crevasses, or joint planes, close up, and the cleavage planes, or veined structure, is strongly developed. When the ice has passed through the gorge of the valley, the pressure is relieved, the cleavage planes disappear, and the crevasses, or joints, open in planes perpendicular to the lines of *minimum pressure*, or, if you like, *maximum extension*.

The mechanical, or pressure theory, of cleavage and joints, is now generally received by geologists ; although many interesting questions connected with it are still debated. Mr. Sorby, by means of microscopical exami-

nations of cleaved rocks, has arrived at results very similar to my own, which are based altogether on measurements of the relative proportions of fossils distorted by cleavage.

There can be no doubt but that the study of glacier-structure will eventually throw light on the mechanical structure of cleaved rocks, and *vice versâ*.

THE END.

LONDON:
Printed by SPOTTISWOODE & Co.
New-street Square.